2012 Exploration Medical Capability Standing Review Panel

Research Plan Review for:

The Risk of Unacceptable Health and Mission Outcomes Due to Limitations of In-flight Medical Capabilities

Final Report

I. Executive Summary and Overall Evaluation

The 2012 Exploration Medical Capability (ExMC) Standing Review Panel (from here on referred to as the SRP) participated in a WebEx/teleconference with representatives from the Human Research Program (HRP) ExMC Element and HRP management (list of participants is in Section VIII of this report) on November 2, 2012 to review the Research Plan for the Risk of Unacceptable Health and Mission Outcomes Due to Limitations of In-flight Medical Capabilities in the Human Research Program's (HRP) Integrated Research Plan (IRP Rev. D).

The SRP strongly agrees with the updated wording of the ExMC risk title as well as of the five updated ExMC gaps included in the pilot effort to update the IRP gaps. The updated gaps expresses risks as the end states of concern, rather than (as had been the case previously) as processes of recognizing, diagnosing, or treating various medical problems. The new method of describing the gaps is an improvement because now end states are presented and end states can be final common pathways for numerous improvements in medical capabilities, such as mass, power, volume, training, and crew time, as well as to in-flight medical events and outcomes. The SRP understands that the remaining gaps will be updated in FY13. NASA funding priorities include medical capabilities but even a carefully constrained investment in this area could easily reach to many times the entire NASA budget. Therefore, the key challenge is to address only the highest medical capabilities requirements.

The updated ExMC research plan identified 30 active gaps, including 12 that were high priority, seven that were medium priority, four that were low priority, three that were on hold, and four that need to be closed. The SRP thinks that these gaps were appropriately classified. The SRP thinks that the proper gaps have been identified to address the risk. All the gaps are relevant and the SRP sees no missing gaps. The appropriate targets for gap closure have been identified. The interim stages are appropriate; however in many cases the estimated percentages of completion to date have not been clearly explained. The complete list of gaps and associated tasks for all the gaps was clearly laid out and appropriate. Overall, the SRP thinks that the proper tasks have been identified to fill the gaps.

The SRP thinks that medical capabilities should address the highest gaps in terms of probability of occurrence and in terms of consequences to mission performance. They should then be further parsed into 1) problems that are not likely to be addressed outside of NASA investments, 2) problems that can be significantly addressed through collaborations, and 3) those problems that are likely to be addressed by others with relevant solutions for

NASA.

The SRP strongly urges NASA to invest in health screening strategies to exclude or to provide a specific mitigation plan for disease risk. These strategies range from family history to genomic analyses. This priority effort could produce the greatest benefit to future mission success in terms of avoidable catastrophic health outcomes.

The SRP once again strongly recommends inclusion of a medical professional to achieve improved care, reduced risk, reduced cost, reduced training time, increased efficiency, and increased autonomy in exploration missions. The updated research plan acknowledges this need, particularly as it involves unanticipated problems, and in so doing enhances the credibility and strength of the recommended tasks and projects. The SRP has considered this one issue the most important and critical to the success of the ExMC element objectives and to exploration missions in general. Also of high priority for investment are high probability problems with serious consequences to mission performance not addressed outside of NASA. Examples include radiation sickness, consequences of microgravity, and extreme isolation. Radiation is an example of a specific exposure risk for astronauts that could produce unforeseen medical problems. At this point, the best preparation for unexpected medical issues on an extended space mission would be inclusion of one or more crewmembers with extensive medical experience, possibly with a neurological focus, and a background of improvising in austere and isolated environments.

The SRP strongly recommends application of an integrative approach to mental and physical health resilience. This may be the most potent countermeasure to a variety of high-risk medical issues ranging from infection and healing to mental health. The strong link between psychological stress and disease has become increasingly apparent in the past decade, and meditation, mindfulness training, as well as personal health habits such as exercise and diet, can provide major benefits to brain health and consequent physical health and performance. Thus, a high priority investment in the development of optimized astronaut health habits may be one of the most significant moderators of the adverse consequences of isolation stress and some of the risks of a microgravity environment (e.g., healing and infection).

It is not clear how certain solution approaches have been selected over other options. As an example, for the task on ultrasound-based treatment of kidney stones, it is not apparent to the SRP that other approaches to the mitigation of the risk of large stone formation have been investigated. Dietary, physical, and pharmacological approaches to preventing bone loss and reducing stone formation may be more effective and less intrusive than “pushing” stones out of the kidneys with ultrasound.

In conclusion, the SRP thinks that the ExMC Element is to be congratulated for reducing the many types of medical risks for space exploration into the current research plan. This plan is appropriate for the needs of NASA, comprehensive, and well organized, but at the same time not overly excessively detailed. The current tasks are targeting high priority medical capabilities needs and address high-risk problems. Additionally, the SRP commends the ExMC Element for the development and progress on key associated work in

support of the research plan such as dissemination of mission-related medical data/information through the Human Research Wiki and progression of the Exploration Medical System Demonstration (EMSD) and Integrated Medical Model (IMM) project.

II. Critique of Gaps and Tasks for the Risk of Unacceptable Health and Mission Outcomes Due to Limitations of In-flight Medical Capabilities

Gaps and Tasks:

ExMC 1.01: Inadequate information on preflight medical screening capabilities for exploration class missions

Tasks:

- Cardiovascular Imaging and Strategies to Mitigate the Risk for Cardiac Events in Astronauts During Prolonged Spaceflight – PI: Benjamin Levine, Ph.D. – University of Texas Southwestern Medical Center at Dallas
- Comparison of Open vs. Closed Access Wiki Models for the Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Technology Watch – PI: Michael Krihak, Ph.D. – NASA Johnson Space Center
- Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center

ExMC 1.02: Inadequate information on genetic screening technology (MERGED WITH ExMC 1.01)

ExMC 1.03: Inadequate information on the individual susceptibility to hypobaric environments (e.g. 7.2 psi lunar habitat) (CLOSED)

Task:

- Data Mining/Identification of Characteristics Associated with Susceptibility to Hypobaric Environments – Task completed

ExMC 2.01: We do not know the quantified mission and crew health consequences due to medical events for exploration – class missions

- In the target for closure of this gap, the SRP recommends that for model estimates of medical events to be statistically indistinguishable from in-flight empirical data, that NASA use overlapping Confidence Intervals (CIs) to be able to claim this statistical equivalence. A list of 14 aspects of a health model was listed with cumulative progress reported to be from 2-15% of completion. The SRP recommends that the report explain more clearly how the cumulative progress percentages were calculated. Currently when we are early in the model development process, it is not important to be exact in the cumulative progress estimates, but in the future, at such time as when NASA is expected to be closer to completion on these 14 elements, then it will be important to be able to explain and define exactly how higher performance numbers will have been calculated.

Tasks:

- Integrated Medical Model (IMM) – Task completed
- Integrated Medical Model - Chest Injury Module – Task completed
- Integrated Medical Model - Head Injury Module – Task completed
- Integrated Medical Model - Abdominal Injury Module – PI: Beth Lewandowski, Ph.D. - NASA Glenn Research Center
- Integrated Medical Model - Bayesian Analysis – Task completed
- Integrated Medical Model - Neck Injury Module – PI: John Brooker, Ph.D. – NASA Glenn Research Center
- Probabilistic Analysis of Renal Stones in US Astronauts – PI: Jerry Myers, Ph.D. – NASA Glenn Research Center
- Comparison of Open vs. Closed Access Wiki Models for the Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Data Request for Sleep-Deprivation Medical Intervention Forecasting (SDMIF) – Task completed
- Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center

ExMC 2.02: We do not know the quantified crew health and mission impacts of including a physician crew medical officer on exploration missions

- NASA is quantifying the impact of physician versus non-physician on the Crew Health Index, Evacuation, and loss of Life. The SRP still believes that the need for a physician is essential on long-duration missions (e.g., to Mars or an asteroid), that it is a likely conclusion that the model will demonstrate this necessity. The SRP would even question the model's assumptions in the event that physician participation in such a long mission is not deemed to be critically important.

Tasks:

- Quantify Impacts of Including Various Levels of Clinical Training Within the Crew – PI: Anil Menon, M.D. – NASA Johnson Space Center
- Comparison of Open vs. Closed Access Wiki Models for the Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Technology Watch – PI: Michael Krihak, Ph.D. – NASA Johnson Space Center
- Long-Duration Cross-Training Feasibility and Methods (Pre-flight and Onboard)
- ExMC Support of Medical Scenarios for the Autonomous Mission Operation (AMO) Test – PI: Victor Hurst, Ph.D. – NASA Johnson Space Center

ExMC 3.01: We do not know the optimal training methods for in-flight medical conditions identified on the Space Medicine Exploration Medical Condition List taking into account the Crew Medical Officer's clinical background

- This gap is being appropriately closed with a systematic analysis of the effectiveness of the current International Space Station (ISS) Crew Medical Officer (CMO) training regimen and the identification of the skill sets needed by CMOs for particular class missions. Development of an appropriate assessment of the training processes for various medical conditions should incorporate analysis of behavioral health as well as the use of technology requiring optimal human factors.

Tasks:

- Data Mining of Post-Flight Medical Crew Debriefs for Information on Crewmember Medical Training Effectiveness – Task completed
- Evaluation of Task-Skill-Knowledge JIT techniques for medical and other emergency events - Planned task
- Medical Proficiency Training – Task completed
- Tools and Methods to Ensure Training Retention for Long-Duration Missions – Planned task
- Comparison of Open vs. Closed Access Wiki Models for the Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Technology Watch – Michael Krihak, Ph.D. – NASA Johnson Space Center
- ExMC Support of Medical Scenarios for the Autonomous Mission Operation (AMO) Test – PI: Victor Hurst, Ph.D. – NASA Johnson Space Center

ExMC 3.02: Lack of knowledge about the current state of the art in telementoring/telemedicine as a tool for assisting crewmembers to diagnose and treat medical conditions that occur in space flight (CLOSED)

Tasks:

- Data Mining for Telementoring Studies and Practices – Task completed
- Telemedicine Workshop – Task completed
- Comparison of Open vs. Closed Access Wiki Models for the Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center

ExMC 3.03: Inadequate information on capabilities for in-flight screening and diagnosis of conditions on the Space Medicine Exploration Medical Condition List

Tasks:

- Determine Requirements for In-Flight Periodic Health Status Exams Based on Space Medicine Exploration Medical Condition List – Task completed
- Comparison of Open vs. Closed Access Wiki Models for the Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Technology Watch – PI: Michael Krihak, Ph.D. – NASA Johnson Space Center

ExMC 4.01: Lack of guided medical procedure system that integrates with medical hardware

Tasks:

- Assisted Medical Procedures (AMP) (formerly: Advanced Integrated Clinical System – Guided Medical Procedure System) – PI: Victor Hurst, Ph.D. – NASA Johnson Space Center
- Integration of iRevive with the Lightweight Trauma Module – Task completed

- Comparison of Open vs. Closed Access Wiki Models for the Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Technology Watch – PI: Michael Krihak, Ph.D. – NASA Johnson Space Center
- Information Integration for Electronic Procedures – Planned task
- Advanced Concepts for Information Integration and Presentation – Planned task
- ExMC Support of Medical Scenarios for the Autonomous Mission Operation (AMO) Test – PI: Victor Hurst, Ph.D. – NASA Johnson Space Center

ExMC 4.02: Limited non-invasive diagnostic imaging capability and techniques to diagnose conditions on the Space Medicine Exploration Medical Condition List

Tasks:

- Combined Scanning Confocal Ultrasound Diagnostic and Treatment System for Bone Quality Assessment and Fracture Healing – PI: Yi-Xian Qin, Ph.D., SUNY – The State University of New York
- Non-Ultrasound Imaging Device – Task completed
- Intuitive Ultrasound Catalog for Autonomous Medical Care – Task completed
- Flexible Ultrasound System – PI: William Thompson, Ph.D. – NASA Glenn Research Center
- Ultrasound Fracture Diagnosis in Space – Task completed
- Validation of On-Orbit Methodology for the Assessment of Cardiac Function and Changes in the Circulating Volume Using Ultrasound and Braslet-M Occlusion Cuffs, SDTO 17011 U/R – Task completed
- Comparison of Open vs. Closed Access Wiki Models for the Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Wideband Single Crystal Transducer for Bone Characterization – PI: Kevin Snook, Ph.D., TRS Ceramics, Inc.
- Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Technology Watch – PI: Michael Krihak, Ph.D. – NASA Johnson Space Center
- Multi-Use Near-Infrared Spectroscopy System for Spaceflight Health Applications - Planned task

ExMC 4.03: Limited capability to treat back/neck pain and injuries in the space flight environment

Tasks:

- Data Mining for Intervertebral Disk Damage – Task completed
- Risk of Intervertebral Disc Damage After Prolonged Spaceflight – PI: Alan Hargens, Ph.D. – University of California, San Diego
- Sonographic Astronaut Vertebral Examination – PI: Scott Dulchavsky, M.D., Ph.D. – Henry Ford Hospital
- Comparison of Open vs. Closed Access Wiki Models for the Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center

- Understand Back/Neck Pain Etiology – PI: Jennifer Fogarty, Ph.D. – NASA Johnson Space Center
- Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Technology Watch – PI: Michael Krihak, Ph.D. – NASA Johnson Space Center

ExMC 4.04: We do not know what technologies can be used to provide supplemental oxygen to ill crewmembers from onset of illness through landing and recovery and also minimize the local and cabin oxygen buildup to avoid increasing the risk of fire.

- This gap seeks to prevent the local buildup of oxygen, which can be a fire hazard. The three targets for closure of this gap and the one metrics for interim progress are appropriate. As mentioned previously, the SRP recommends that the research plan explain more clearly how the cumulative progress percentages were calculated.

Tasks:

- Development of Pressure Swing Adsorption Technology for Spaceflight Medical Oxygen Concentrators – PI: James Ritter, Ph.D. – University of South Carolina
- Evaluation of Oxygen Concentrators at Altitude – Task completed
- Medical Oxygen Fire Safety – Task completed
- Portable Cathode-Air-Vapor-Feed Electrochemical Medical Oxygen Concentrator – PI: Alan Cisar, Ph.D. – Lynntech, Inc.
- ISS Flight Demonstration of Oxygen Concentrator – Planned task
- Lightweight Trauma Module – Task completed
- Comparison of Open vs. Closed Access Wiki Models for the Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Technology Watch – PI: Michael Krihak, Ph.D. – NASA Johnson Space Center

ExMC 4.05: Lack of minimally invasive in-flight laboratory capabilities with limited consumables required for diagnosing identified Exploration Medical Conditions

- This gap for development of technology for in-flight analysis of body fluids is an important gap that is being appropriately advanced. The targets for closure (2017 – TRL 6 and 2019 – TRL7-8) are rough approximations and these deadlines could slip for many reasons. The SRP recommends that the ExMC Element explain more clearly how the target dates were estimated and how the metrics for interim progress were estimated. A technology that NASA should following the tech watch program is keep in mind is lab-on-a-cellphone for both cytometry and (even recently) quantitative measurements of immunologic-based assays of infections agents.

Tasks:

- In-flight Blood Analysis Technology for Astronaut Health Monitoring – PI: Yu-Chong Tai – California Institute of Technology
- Nanoscale Test Strips for Multiplexed Blood Analysis – PI: Eugene Chan – The DNA Medicine Institute
- Reusable Handheld Electrolytes and Lab Technology for Humans – Task completed
- Comparison of Open vs. Closed Access Wiki Models for the Human Research Wiki – PI:

Yael Barr, M.D. – NASA Johnson Space Center
- Lander/Outpost Inflight Lab Analysis-ARC – PI: Michael Krihak, Ph.D. – NASA Johnson Space Center
- Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Technology Watch – PI: Michael Krihak, Ph.D. – NASA Johnson Space Center

ExMC 4.06: Limited capability to stabilize and treat bone fractures

Tasks:
- Combined Scanning Confocal Ultrasound Diagnostic and Treatment System for Bone Quality Assessment and Fracture Healing – PI: Yi-Xian Qin, Ph.D., SUNY – The State University of New York
- Comparison of Open vs. Closed Access Wiki Models for the Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Technology Watch – PI: Michael Krihak, Ph.D. – NASA Johnson Space Center
- Methods/Technologies for Treatment of Bone Fracture – Planned task

ExMC 4.07: Limited wound care capability to improve healing following wound closure

Tasks:
- Data Sharing Activity to Gather Evidence for Impaired Healing Risk – Planned task
- Comparison of Open vs. Closed Access Wiki Models for the Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Human Research Wiki – PI: Y ael Barr, M.D. – NASA Johnson Space Center
- Technology Watch – PI: Michael Krihak, Ph.D. – NASA Johnson Space Center

ExMC 4.08: Limited capability to treat muscle, ligament, and tendon injuries

Tasks:
- Development of Methods/Technologies for Treating MLT Injuries – Planned task
- Comparison of Open vs. Closed Access Wiki Models for the Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Technology Watch – PI: Michael Krihak, Ph.D. – NASA Johnson Space Center

ExMC 4.09: Lack of medical suction and fluid containment capability for chest tube and airway management in partial gravity and microgravity environments

Tasks:
- Development of Methods/Technologies for Treating MLT Injuries – Planned task
- Comparison of Open vs. Closed Access Wiki Models for the Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Technology Watch – PI: Michael Krihak, Ph.D. – NASA Johnson Space Center

ExMC 4.10: Lack of rapid vascular access capability for space flight (CLOSED)

Tasks:

- Intraosseous (IO) Access Device Demonstration – Task completed

ExMC 4.11: Limited dental care capabilities

Tasks:

- Exploration Dental Capabilities for EMSD – PI: David Rubin, Ph.D. – NASA Johnson Space Center
- CDDF/Innovative Treatments of Dental Emergencies for Lunar and Exploration Missions – Task completed
- Development of Methods/Technologies for Dental Conditions – PI: Anil Menon, M.D. – NASA Johnson Space Center
- Comparison of Open vs. Closed Access Wiki Models for the Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Technology Watch – PI: Michael Krihak, Ph.D. – NASA Johnson Space Center

ExMC 4.12: Lack of in situ intravenous (IV) fluid generation and resource optimization capability

Tasks:

- Fluid Resuscitation - Closed Loop – Planned task
- Intravenous Fluid GENeration for Exploration Missions – Task completed
- IVGEN Gap Analysis – PI: John McQuillen, Ph.D. – NASA Glenn Research Center
- Comparison of Open vs. Closed Access Wiki Models for the Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Technology Watch – PI: Michael Krihak, Ph.D. – NASA Johnson Space Center

ExMC 4.13: Limited capability to diagnose and treat a renal stone during an exploration mission

Tasks:

- Smart Therapeutic Ultrasound Device for Mission-Critical Medical Care – PI: Lawrence Crum, Ph.D. - University of Washington
- Comparison of Open vs. Closed Access Wiki Models for the Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Technology Watch – PI: Michael Krihak, Ph.D. – NASA Johnson Space Center
- ExMC Support of Medical Scenarios for the Autonomous Mission Operation (AMO) Test – PI: Victor Hurst, Ph.D. – NASA Johnson Space Center

ExMC 4.14: Lack of efficient medical consumable inventory tracking system that provides data on overall usage and usage rate and integrates securely with vehicle inventory management system

Tasks:

- Medical Consumables Tracking - GRC – PI: John Zoldak, Ph.D. – NASA Glenn Research Center
- Comparison of Open vs. Closed Access Wiki Models for the Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Technology Watch – PI: Michael Krihak, Ph.D. – NASA Johnson Space Center

ExMC 4.15: Lack of medication usage tracking system that includes automatic time stamping and crew identification

Tasks:

- Medical Consumables Tracking - GRC – PI: John Zoldak, Ph.D. – NASA Glenn Research Center
- Comparison of Open vs. Closed Access Wiki Models for the Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Technology Watch – PI: Michael Krihak, Ph.D. – NASA Johnson Space Center

ExMC 4.16: Lack of technique or procedure to draw injectable medication into a syringe without bubble formation or bubble removal prior to medication delivery (CLOSED)

Tasks:

- Air/Fluid Separation in a Syringe in a Microgravity Environment – Task completed
- Injectible Medication Study for ISS Medical Kit Redesign

ExMC 4.17: Lack of adequate protection for medications to preserve stability and shelf-life in exploration class missions

Tasks:

- Development of methods/technologies for protecting medications in spaceflight – Planned task
- Comparison of Open vs. Closed Access Wiki Models for the Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Technology Watch – PI: Michael Krihak, Ph.D. – NASA Johnson Space Center

ExMC 4.18: Limited biomedical monitoring capability for exploration extravehicular activity suits

Tasks:

- Biomedical Sensors (EVA) ARC – Task completed
- Noninvasive Biosensor Algorithms for Continuous Metabolic Rate Determination – PI: Babs Soller, Ph.D. – Reflectance Medical Inc.
- Comparison of Open vs. Closed Access Wiki Models for the Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Technology Watch – PI: Michael Krihak, Ph.D. – NASA Johnson Space Center

ExMC 4.19: Limited biomedical sensing capabilities for intravehicular activities (such as performing periodic clinical status evaluations and contingency medical monitoring)

Tasks:

- Development of Methods/Technologies for Intravehicular Activity Biomedical Monitoring – Planned task
- Lightweight, Wearable Metal Rubber-Textile Sensor for In-Situ Lunar Autonomous Health Monitoring – Task completed
- Lunar Health Monitor: A Wearable System to Monitor Astronaut Health Status – Task completed
- Wearable Health Monitoring Systems – Task completed
- Comparison of Open vs. Closed Access Wiki Models for the Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Biomedical Sensors (IVA) – Duncan Atchison, Ph.D. – Lockheed Martin
- Biosensor Integration – PI: Devon Griffin, Ph.D. – NASA Glenn Research Center
- Biomedical Sensors - PI: Duncan Atchison, Ph.D. – Lockheed Martin
- Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Technology Watch – PI: Michael Krihak, Ph.D. – NASA Johnson Space Center
- Biosensors for EMSD – PI: David Rubin, Ph.D. – NASA Johnson Space Center

ExMC 4.20: Lack of a system to manage medical data collected from the patient in space flight that integrates with ground operations (MERGED WITH ExMC 5.01)

ExMC 4.21: Limited eye wash capability to treat chemical eye exposure in partial gravity and microgravity environments

Tasks:

- Development of Methods/Technologies for Eye Wash Capability – Planned task
- Comparison of Open vs. Closed Access Wiki Models for the Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Technology Watch – PI: Michael Krihak, Ph.D. – NASA Johnson Space Center

ExMC 4.22: Limited capability to diagnose and treat radiation sickness

Tasks:

- Development of Methods/Technologies for Treating Radiation Sickness – Planned task

- Comparison of Open vs. Closed Access Wiki Models for the Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Technology Watch – PI: Michael Krihak, Ph.D. – NASA Johnson Space Center

ExMC 4.23: Limited capability to auscultate internal sounds of the body in a noisy, space flight environment

Tasks:

- Development of Methods/Technologies to Auscultate and Capture Body Sounds in a Noisy – Planned task
- Comparison of Open vs. Closed Access Wiki Models for the Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Technology Watch – PI: Michael Krihak, Ph.D. – NASA Johnson Space Center

ExMC 4.24: Lack of knowledge regarding the treatment of conditions on the Space Medicine Exploration Medical Condition List in remote, resource poor environments

Tasks:

- Research Treatment of Relevant Medical Conditions in Remote, Resource Poor Environments – PI: Anil Menon, M.D. – NASA Johnson Space Center
- Comparison of Open vs. Closed Access Wiki Models for the Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Technology Watch – PI: Michael Krihak, Ph.D. – NASA Johnson Space Center
- ExMC Support of Medical Scenarios for the Autonomous Mission Operation (AMO) Test – PI: Victor Hurst, Ph.D. – NASA Johnson Space Center

ExMC 4.25: Lack of capability to deliver medication to a crewmember in a pressurized suit

Tasks:

- Spaceflight Injectable Delivery System – PI: Aaron Weaver, Ph.D. – NASA Glenn Research Center
- Comparison of Open vs. Closed Access Wiki Models for the Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Technology Watch – PI: Michael Krihak, Ph.D. – NASA Johnson Space Center

ExMC 4.26: Limited capability to diagnose and treat pulmonary or systemic disease due to non-terrestrial dust exposure

Tasks:

- Development of methods/technologies to monitor and treat disease caused by non-

terrestrial dust exposure – Planned task
- LADTAG Lunar Dust Health Standard – PI: John James, Ph.D. – NASA Johnson Space Center
- Review and Assess State of Knowledge Regarding the Acute or Chronic Cardiovascular Toxicity of Mineral Dusts – Planned task
- Clearance of Particles Depositing in the Human Lung in Low Gravity – PI: Kim Prisk, Ph.D. – University of California, San Diego
- Comparison of Open vs. Closed Access Wiki Models for the Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Technology Watch – PI: Michael Krihak, Ph.D. –NASA Johnson Space Center

ExMC 4.27: Limited capability to sterilize medical equipment in space flight

Tasks:
- Development of Methods/Technologies to Sterilize Medical Equipment in Spaceflight – Planned task
- Comparison of Open vs. Closed Access Wiki Models for the Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Technology Watch – PI: Michael Krihak, Ph.D. – NASA Johnson Space Center

ExMC 5.01: Lack of end-to-end medical data management infrastructure for exploration class missions

Tasks:
- Exploration Medical System Demonstration on ISS – PI: David Rubin, Ph.D. – NASA Johnson Space Center
- Middleware for EMSD – PI: David Rubin, Ph.D. – NASA Johnson Space Center
- Electronic Medical Records – PI: David Rubin, Ph.D. – NASA Johnson Space Center
- Biosensors for EMSD – PI: David Rubin, Ph.D. – NASA Johnson Space Center
- Exploration Dental Capabilities for EMSD – PI: David Rubin, Ph.D. – NASA Johnson Space Center
- Mission Medical Information System – Task completed
- Distributed System for Spaceflight Biomedical Support – PI: Gary Strangman, Ph.D. – Massachusetts General Hospital
- Comparison of Open vs. Closed Access Wiki Models for the Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Mission Extended Medical Enterprise – Task completed
- Human Research Wiki – PI: Yael Barr, M.D. – NASA Johnson Space Center
- Technology Watch – PI: Michael Krihak, Ph.D. – NASA Johnson Space Center
- Exploration Medical System Demonstration (EMSD) Baseline Capability Evaluation using the HDU – PI: Victor Hurst, Ph.D. – NASA Johnson Space Center
- EMSD Ground Demonstration – PI: David Rubin, Ph.D. – NASA Johnson Space Center
- EMSD-Flight Demonstration – PI: David Rubin, Ph.D. – NASA Johnson Space Center

III. Discussion on the strengths and weaknesses of the IRP and identify remedies for the weaknesses, including answering these questions:

Is the Risk addressed in a comprehensive manner?

- Yes, the SRP thinks that the Risk is addressed in a comprehensive manner. The research plan is much improved from the originally reviewed plan with acknowledgement of the need for some medically trained individuals to manage unanticipated problems. The SRP once again strongly recommends inclusion of a medical professional to exploration missions. Medical science is still an art and cannot be simple reduced to algorithms and models. Best solutions in a remote setting will also likely require medical improvisation that calls for experience in human medicine.

Are there obvious areas of potential integration across disciplines that are not addressed?

- Yes. The decision support tools need to be comprehensive and not viewed as separate modules based on body systems. For example, the head is connected to the body - psychological stress can have profound and near term effects on periodontal disease and other forms of infection and, the converse is true that systemic dysfunction can have significant effects on mood and cognition.

IV. Evaluation of the progress in the IRP Rev. D since the 2011 SRP meeting.

- Some of the projects currently supported in the NASA medical capabilities portfolio still appear to be influenced by legacy programs rather than highest priority needs; however, the portfolio has been substantially streamlined and improved since the 2011 SRP meeting.

V. Additional Comments

- The SRP thinks that NASA should be a leader in telemedicine, articulating the need for remote care and autonomous care systems. This should include an activist role with even a small amount of funding to promote the effort, rather than a passive technology watch. Many technologists and clinicians have developed solutions that could be cost-effectively harnessed to produce effective systems for NASA medical capabilities. These include concepts in remote diagnostics, decision support tools, and just-in-time training systems.

VI. Response to the Addendum Question

Each gap within the ExMC research plan is reviewed annually and assigned a priority (high, medium, or low) by the ExMC Advisory Group. The Advisory Group is comprised of ExMC's stakeholders and includes flight surgeons, astronauts, and medical hardware personnel. Charge to panel: Please review the gap priorities and provide comments regarding recommended changes to these priorities.

***The HRP acknowledges that any recommendations or comments to the Statement of Task Addendum will be based only on the scientific and technical data provided. A full prioritization cannot be completed by*

the SRP without other data that has not been provided, such as, budget and schedule constraints.

The updated ExMC research plan identified 30 active gaps, including 12 that were high priority, seven that were medium priority, four that were low priority, three that were on hold, and four that need to be closed. The SRP believes that these gaps were appropriately classified and prioritized. The appropriate targets for gap closure have been identified. The interim stages are appropriate; however in many cases the estimated percentages of completion to date have not been clearly explained. Also, it is not clear how certain solution approaches have been selected over other options. As an example, for the task on ultrasound-based treatment of kidney stones, it is not apparent to the SRP that other more safe, non-procedural approaches to the mitigation of the risk of large stone formation have been investigated.

VII. 2012 Exploration Medical Capability SRP Research Plan Review (WebEx): Statement of Task for the Risk of Unacceptable Health and Mission Outcomes Due to Limitations of In-flight Medical Capabilities

The 2012 Exploration Medical Capability (ExMC) Standing Review Panel (SRP) is chartered by the Human Research Program (HRP) Chief Scientist. The purpose of the SRP is to review the ExMC Element section of the HRP's Integrated Research Plan, Revision D (IRP Rev. D) which is located on the Human Research Roadmap (HRR) website (http://humanresearchroadmap.nasa.gov/). Your report will be provided to the HRP Chief Scientist.

The 2012 ExMC SRP is charged (to the fullest extent practicable) to:

1. Evaluate the ability of the IRP Rev. D to satisfactorily address the Risk by answering the following questions:
   A. Have the proper Gaps been identified to address the Risk?
      i) Are all the Gaps relevant?
      ii) Are any Gaps missing?

   B. Has the appropriate target for closure for the Gap been identified?
      i) Are the interim stages appropriate to close the Gap?

   C. Have the proper Tasks been identified to fill the Gaps?
      i) Are the Tasks relevant?
      ii) Are any Tasks missing?

2. Identify the strengths and weaknesses of the IRP Rev. D, *and* identify remedies for the weaknesses, including answering these questions:
   A. Is the Risk addressed in a comprehensive manner?
   B. Are there obvious areas of potential integration across disciplines that are not addressed?

3. Please evaluate the progress in the IRP Rev. D since your 2011 SRP meeting.

4. Please comment on any important issues that are not covered in #1, #2, or #3 above. If a charge addendum is provided, please address each of the questions as fully as possible.

Additional Information Regarding This Review:

1. Expect to receive review materials at least four weeks prior to the WebEx conference call.

2. Participate in a WebEx conference call on November 1, 2012.
   A. Discuss the 2012 ExMC SRP Statement of Task and address questions about the SRP process.
   B. Receive presentations from the ExMC Element.
   C. Participate in a question and answers session.
   D. Attend Element or Project presentations, question and answer session, and briefing.

3. Prepare a draft final report (within one month of the WebEx/teleconference) that contains a detailed evaluation of the current IRP specifically addressing items #1, #2, #3, and #4 of the SRP charge. The draft final report will be sent to the HRP Chief Scientist and he will forward it to the appropriate Element for their review. The ExMC Element and the HRP Chief Scientist will have 10 business days to review the draft final report and identify any misunderstandings or errors of fact and then provide official feedback to the SRP. The SRP will have 10 business days to address any issues and finalize the 2012 SRP Final Report. The 2012 SRP Final Report will be submitted to the HRP Chief Scientist and copies will be provided to the ExMC Element and also made available to the other HRP Elements. The 2012 SRP Final Report will be made available on the Human Research Roadmap public website (http://humanresearchroadmap.nasa.gov/).

Addendum to the Charge:

Each gap within the ExMC research plan is reviewed annually and assigned a priority (high, medium, or low) by the ExMC Advisory Group. The Advisory Group is comprised of ExMC's stakeholders and includes flight surgeons, astronauts, and medical hardware personnel. Charge to panel: Please review the gap priorities and provide comments regarding recommended changes to these priorities.

**The HRP acknowledges that any recommendations or comments to the Statement of Task Addendum will be based only on the scientific and technical data provided. A full prioritization cannot be completed by the SRP without other data that has not been provided, such as, budget and schedule constraints.

VIII. ExMC SRP Research Plan Review WebEx/Teleconference Participants

SRP Members:
Nitza Cintron, M.D., Ph.D. (Chair) – University of Texas Medical Branch at Galveston
Eric Dutson, M.D. – University of California, Los Angeles
Colonel Karl Friedl – US Army Medical Research and Material Command
Mae Jemison, M.D. – The Jemison Group, Inc.
David Klonoff, M.D. – Mills-Peninsula Health Services

NASA Ames Research Center (ARC):
Michael Krihak, Ph.D.
Fritz Moore, Ph.D.
Tianna Shaw

NASA Glenn Research Center (GRC):
Sandra Olson, Ph.D.
Sam Hussey
Marsha Nall
William Thompson, Ph.D.

Headquarters:
Bruce Hather, Ph.D.

NASA Johnson Space Center (JSC):
Douglas Butler
Duane Chin
Victor Hurst, IV, Ph.D.
Tammie McGrath
Anil Menon, M.D., M.P.H.
Lisa Milstead
Jack Rasbury
Baraquiel Reyna, D.Eng.
David Rubin
Ronak Shah, M.D., M.P.H.
Susan Steinberg, Ph.D.
Lisa Stephenson
Michelle Urbina
Sharmi Watkins, M.D., M.P.H.

NASA Research and Education Support Services (NRESS):
Tiffin Ross-Shepard

National Space Biomedical Research Institute (NSBRI):
Jeff Chancellor, Ph.D.

IX. ExMC Standing Review Panel Roster

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